PROLOGUE

The September 1, 1999, accident at the Savannah River Site's FB-Line facility occurred when plutonium was released from a failed bagless transfer can, resulting in plutonium intakes by at least seven workers (additional workers are being evaluated). The bagless transfer can was considered by contractor management to be an integral component in the overall safety strategy for the FB-Line. Despite this reliance on the canister's integrity, adequate quality assurance controls were not in place to ensure that a can with a failed weld would not be stored in the FB-Line vault.

Two root causes were identified for this accident: Quality assurance on the bagless transfer system canister was not adequate to identify the weld defect, and implementation of integrated safety management for plutonium vault operations was inadequate to provide worker protection during interim plutonium storage and handling.

Once the containment system (the bagless transfer can) failed, the physical environment of the vault storage location and adjacent vestibule contributed to the accident. Near stagnant ventilation made operation of the High Volume Air Monitor less than optimum. Command and Control and communication following the accident were not adequate, and contributed to confusion over material control and accountability requirements and delays in alarm response.

This accident highlights the importance of ensuring an effective Integrated Safety Management System approach to operations. Several of the conclusions reached by the Accident Investigation Board are similar to conclusions reached during the 1997 Type B accident investigation of the plutonium intake by a crane operator at the Savannah River Site's F-Canyon. Specifically, parallels can be drawn in the areas of casualty response to radiological events and procedure compliance for routine or low hazard work. FB-Line had made progress in establishing an Integrated Safety Management System, including completion of a Phase II integrated safety management review in 1997. However, during this accident investigation, deficiencies were identified in each of the five core functions of integrated safety management. There is a need for the contractor and the Department of Energy Savannah River Operations Office to analyze FB-Line operations and take appropriate corrective action to ensure feedback and improvement aspects of integrated safety management are effectively implemented.

EXECUTIVE SUMMARY

INTRODUCTION

On September 1, 1999, at least seven personnel working in an area inside the Department of Energy (DOE) Savannah River Site (SRS) FB-Line facility received intakes of plutonium (additional workers are being evaluated). The plutonium intakes were determined through analysis of chest counting data and screening of bioassay samples provided by the subject individuals. Estimated doses were initially provided for four of the individuals on September 9, 1999. One individual's estimated dose exceeded 10 rem total effective dose equivalent but was less than 25 rem, meeting the criteria for a Type B accident investigation as defined in DOE Order 225.1A, *Accident Investigations*. The DOE Savannah River Operations Office (SR) categorized the accident on September 10, 1999, in accordance with DOE Order 225.1A. On September 13, 1999, the SR Manager formed a Type B Accident Investigation Board (Board).

In conducting its investigation, the Board used various analysis techniques, including events and causal factors charting and analysis, barrier analysis, change analysis, and root cause analysis. The Board walked down the accident site and relevant facility features, reviewed events surrounding the accident and recovery actions, conducted extensive interviews and document reviews, and performed analyses to determine the causal factors that contributed to the accident, including management system deficiencies. Relevant management systems and factors that could have contributed to the accident were evaluated using the core functions of DOE's Integrated Safety Management System, as described in DOE P 450.4, *Safety Management System Policy*.

ACCIDENT DESCRIPTION

On September 1, 1999, FB-Line reported an occurrence involving personnel contamination with positive nasal/saliva smears (SR-WSRC-FBLINE-1999-0026). The FB-Line facility was performing routine vault operations when the high volume air monitor (HVAM) alarmed. Personnel involved suspended operations, secured the vault and exited the area. The HVAM planchet collecting an air sample from inside the vault read 80,000 disintegrations per minute (dpm) alpha. Radiological Control Operations personnel surveyed the retrospective air sample filter paper in the vault vestibule area and it read 80,000 dpm alpha. A subsequent survey of the filter paper, conducted after exiting the vestibule area, indicated 140,000 dpm alpha. After personnel exited the Contamination Area and monitored on the personal contamination monitor model 1B, two persons received an alarm during monitoring. Alarm Response Procedures and Abnormal Operating Procedures were initiated. All personnel involved in the vault operations were subsequently escorted to the F-Canyon Decontamination Facility located in building 221-F. Nasal and saliva smears were obtained from all affected individuals. Smears were positive for six of the individuals involved in the vault activities. Personnel were moved to medical facilities in buildings 704-F and 719-H for further evaluation and processing. The FB-Line facility established the affected areas of the facility as Contamination Areas and confirmed that the boundaries to the areas were intact.

CAUSAL FACTORS

Causal factors are the events and conditions that produced or contributed to the accident. The direct cause is defined as the immediate event or condition causing the accident. The Board determined the direct cause of the accident was the release of plutonium from a defective bagless transfer can, resulting in inhalation of plutonium by FB-Line workers.

Root causes are factors that, if corrected, would prevent recurrence of the same or similar accidents. The Board identified two root causes of the September 1 accident:

- Quality assurance on the bagless transfer system canister was not adequate to identify the weld defect.
- Implementation of integrated safety management for plutonium vault operations was inadequate to provide worker protection during interim plutonium storage and handling.

Contributing causes are defined as events or conditions that collectively with other causes increased the likelihood of an accident, but individually did not cause it. The Board identified as contributing causes less than adequate performance in the following areas: verbatim compliance with procedures, vault/vestibule ventilation, vault HVAM alarm response, radiological work practices, Material Control and Accountability response under abnormal conditions, security post orders, pre-job briefs, Command and Control, and vault HVAM operation.

The following management issues were identified during the investigation but were determined not to be causal factors:

- Lack of established SRS standards for vault and vestibule airflow.
- Lack of established SRS standards for minimum airflow to optimize HVAM performance.
- Weakness in personnel survey techniques and capabilities for detection of alpha contamination.
- Weakness in utilization of personnel decontamination facilities.

CONCLUSIONS AND JUDGMENTS OF NEED

Table ES-1 presents the Board's conclusions and judgments of need. The Board's conclusions are based on facts and pertinent analytical results. From the conclusions, the Board developed judgments of need to guide managers in developing follow-up actions. Follow-up actions should include physical, managerial, administrative and safety management system controls and practices necessary to resolve the conditions identified in the conclusions for each judgment of need.

Table ES-1. Conclusions and Judgments of Need

Conclusions	Judgments of Need
The bagless can was not subject to an adequate quality assurance program during production commensurate with its role as a primary barrier protecting the workers. Areas requiring particular emphasis include the visual inspection and the leak checks (gross and helium), both of which failed to detect the hole in the bagless can weld.	Westinghouse Savannah River Company (WSRC) needs to define appropriate quality assurance controls for the bagless can, develop remedial measures for cans already produced, and evaluate whether remedial measures are necessary for all other types of containers in the vault. WSRC needs to provide qualified weld inspectors with appropriate training and equipment to enable an independent inspection of weld quality for bagless transfer system cans. WSRC needs to evaluate the operation, maintenance, and calibration of the leak detection system to ensure satisfactory weld failure detection.

Conclusions	Judgments of Need
WSRC management expectations regarding following procedures and work standards were not enforced for conduct of operations. For example, instances of non-compliance with operating procedures and Radiological Work Permits (RWP) occurred prior to and during the accident. Additionally, communications between workers during the event did not permit affected personnel to understand the nature of the event, and communications between affected workers and supervision did not result in adequate supervisory direction during the event. Pre-Job Briefings did not include comprehensive coverage of radiological contingencies.	WSRC management needs to communicate and enforce expectations regarding conduct of operations. WSRC needs to evaluate the required content of pre-job briefings and ensure that required topics are appropriately covered.
WSRC management expectations regarding following procedures and work standards were not enforced for radiological controls. For example, there was failure to perform an RWP-required survey of items prior to handling, failure to completely characterize work site radiological conditions, failure to completely survey failed can prior to initiation of decontamination, failure to terminate work when the RWP suspension guide limit was reached, failure to utilize radiological boundaries at the Contamination Area/Airborne Radioactivity Area to Contamination Area transition, and failure to survey personnel exiting the vault following receipt of the HVAM alarm.	WSRC management needs to communicate and enforce expectations regarding conduct of radiological operations.
Command and Control during the material handling evolution and response to the HVAM alarm was inadequate.	WSRC management needs to ensure command and control concepts are understood and implemented by supervisory personnel.
The facility drill program did not include day crew operations and security group personnel likely to be affected by an actual event.	WSRC management needs to improve the facility drill program by including all organizations that could be impacted by actual facility events.

Conclusions	Judgments of Need
Issues identified for this accident are similar to those identified in the 1997 DOE Type B Accident Investigation report of a plutonium intake by a crane operator at the SRS F-Canyon. Similarities include failure to adequately characterize work site radiological conditions, inadequate job planning/work package preparation/pre-job briefs/ALARA reviews, failure to ensure verbatim compliance with procedures, inadequate specification of who was responsible for the job, failure to perform adequate Job Hazard Analyses, and inadequate management analysis of operating conditions.	WSRC management and DOE-SR line management need to (a) analyze the adequacy of F-Canyon lessons learned implementation and develop corrective actions, (b) validate any corrective actions already implemented by FB-Line as a result of the F-Canyon accident, and (c) determine why corrective actions taken in response to the F-Canyon accident investigation report were not effective in mitigating the effects of this accident.
Due to lack of facility guidance, operations staff were unclear of Material Control and Accountability requirements during an abnormal event.	WSRC needs to include Material Control and Accountability requirements during abnormal conditions in facility procedures and train affected personnel.
WSRC and Wackenhut Services Incorporated-Savannah River Site (WSI-SRS) lack adequate interface during abnormal conditions.	WSRC and WSI-SRS need to develop a plan for improving communications and coordination between operations, Radiological Control Operations, and WSI-SRS during abnormal conditions.
Security post orders did not contain response requirements for abnormal conditions.	WSI-SRS needs to ensure security post orders contain response requirements for abnormal conditions.
WSRC and DOE-SR have been presented with many opportunities in the past to rectify problems identified either by them or others that resurfaced in this investigation and contributed to the accident.	WSRC and DOE-SR senior management need to determine the root causes of ineffectiveness in their feedback and improvement mechanisms and develop appropriate corrective action.
WSRC management did not adequately implement integrated safety management for plutonium vault operations.	WSRC senior management, independent of line management, needs to analyze why the breakdown in integrated safety management implementation for plutonium storage and handling activities occurred, and develop appropriate corrective actions. WSRC management needs to (a) analyze FB-Line vault/vestibule operations for worker protection and define appropriate controls, and (b) review other analyses for worker protection within FB-Line for adequacy and correct any identified deficiencies.
DOE-SR did not develop a site-specific technical basis document for interim storage of plutonium-bearing materials.	DOE-SR needs to develop a site-specific technical basis document for interim storage of plutonium-bearing materials.